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Description

The invention relates to a vertical column for removing a liquid from a gas.

There are numerous examples in the petroleum and chemical industry where an entrained liquid has to be removed from a gas. The liquid may be entrained in smaller or larger quantities by a flowing gas, in the form of small or large drops, suspended in the form of a mist, as a plug (especially in pipelines), as a foam, etc.

Well-known examples are water and liquid hydrocarbons in natural gas, liquid absorption agents in a gas treated with such agents and lubricating oil or crude oil in hydrogen or hydrocarbon gas. An argument for the use of a vertical column for removing liquid from gas is that it occupies little ground area, which is particularly advantageous for offshore application on production platforms, but also in refineries.

European patent application, publication No. 048 508, discloses a vertical column for removing a liquid from a gas having a gas inlet, a liquid outlet arranged below the gas inlet and a gas outlet arranged above the gas inlet, in which between the gas inlet and the gas outlet and over the whole cross-section of the column a centrifugal liquid separator is arranged, which centrifugal liquid separator comprises two horizontal trays between which vertical open-ended swirl tubes extend, each from an opening in the lower tray to some distance below a coaxial opening in the upper tray, means for the discharge of secondary gas and of liquid from the space between the trays outside the swirl tubes, and means provided in the lower part of the swirl tubes to impart to the gas a rotary movement about a vertical axis.

During normal operation of the known column, a mixture of gas and entrained liquid is introduced into the column through the gas inlet and flows upwards into the centrifugal liquid separator where entrained liquid is separated from the mixture. Liquid is discharged through the liquid outlet and gas flows through the gas outlet. However, if the velocity of the mixture is relatively high, the residence time of the mixture in the centrifugal liquid separator is relatively short resulting in a poor separation of liquid and gas, especially if the entrained liquid is present in a finely dispersed form.

It is an object of the present invention to provide a compact vertical column for removing a liquid from a gas, wherein sufficient separation is achieved for a large range of gas velocities.

To this end the vertical column according to the invention is characterized in that a horizontal coalescer is arranged between the gas inlet and the centrifugal liquid separator and over the whole cross-section of the column, and in that the gas inlet is provided with a supply and distribution assembly extending horizontally in the column, the assembly consisting of a longitudinal box-like structure having at least one open vertic side with a grid of guide vanes disposed one behind the other, across the column.

It has been found that the maximum gas velocity for which a desirable liquid separation is obtained in a vertical column with the coalescer and the centrifugal separator according to the invention is four times higher than the maximum velocity in a vertical column containing only a horizontal demister mat. If, however, the column comprises just the centrifugal liquid separator, then even at considerably lower gas velocities than the maximum gas velocity which is admissible according to the invention the gases will not be sufficiently dried if the liquid is present in a finely dispersed form.

In practice, the operation of the coalescer in the column according to the invention appears to differ according to the gas velocity. At relatively low gas velocities the coalescer removes all liquid from the gas - the liquid showers down out of the coalescer and is discharged from the bottom of the column. At higher gas velocities, although the coalescer coalesces the liquid drops, they are nevertheless carried by the gas upwardly and out of the coalescer and are removed from the gas in the centrifugal separator.

An aspect that contributes to the enhanced separating capacity of the column according to the invention is the pressure drop over the coalescer, which leads to an ideal distribution of the gas over the column diameter in and above the coalescer, so that the influence of the, necessarily non-ideal, gas inflow to the column is eliminated.

There are numerous horizontal coalescers available for vertical columns. A well-known example is the demister mat. All of these are relatively tenuous (large permeability) and have a relatively large specific (internal) surface area. Their operation is based on drop capture by collision of drops with internal surfaces, followed by drop growth on these surfaces, and finally by removal of the grown drop either by the gas or by gravity.

The centrifugal separator functions as follows. The gas flows upwards, distributes itself over the swirl tubes and is set in rotation. This causes the liquid drops to be flung in the swirl tubes against the tube wall, and under the influence of the upward component of the gas movement the liquid film present on the tube wall, together with a quantity of - secondary - gas, is discharged over the top edge of the swirl tube to the space between the trays outside the swirl tubes. In the meantime the main gas stream - the primary gas - leaves the centrifugal separator via the coaxial openings in the upper tray coaxial with the swirl tubes. In the space between the trays outside the swirl tubes the liquid is separated from the secondary gas by gravity (the gas velocity being low there) and the secondary gas and the liquid are each discharged separately from this space.

An advantage of this type of centrifugal separator that is particularly important at high

gas velocities is that the separated liquid does not shower down in the column and cannot therefore be re-atomized by the upwardly flowing gas below the centrifugal separator. It also saves the coalescer from being showered by falling liquid.

The gas inlet comprises an admittance with a supply and distribution assembly extending horizontally in the column, the supply and distribution assembly including a longitudinal chamber connected to the gas inlet and having at least one open vertical side with a grid of guide vanes disposed one behind the other, across the column. By means of this supply and distribution assembly, the gas is evenly distributed by the guide vanes over the cross-section of the column, which brings about an additional improvement of the liquid separation in the coalescer/centrifugal separator combination. A further advantage is that the supply and distribution assembly separates from the gas any waves of liquid which may suddenly occur in the gas stream, such as can happen, for example, in pipelines for natural gas transport, the separation being effected by the liquid colliding with the guide vanes and falling down inside the column. After having been distributed by the vanes over the column cross-section, the gas flows up to the coalescer.

The horizontal coalescer can have many forms which are known per se amd may, for example, consist of a bed of layers of metal gauze or a layer of vanes or a layer of structured packing. These three sorts of coalescer have the advantage of being commercially available and operating efficiently in the column according to the invention.

The liquid separator is also preferably provided with vertical tube pieces which project down from the coaxial openings in the upper tray into the swirl tubes and have a smaller diameter than these latter. This arrangement enhances the separation between primary gas on the one hand and secondary gas and liquid on the other hand, since these latter cannot get from the swirl tubes into the openings in the upper tray for primary gas.

According to a preferred embodiment, the means for discharging the secondary gas from the space between the trays consist of vertical tubelets through the upper tray, and the means for discharging liquid from the space between the trays consist of one or more vertical discharge pipes which extend from this space to the bottom of the column. This arrangement has the advantage that the secondary gas, after having been separated from liquid in the said space between the trays, is immediately returned to the primary gas, and the liquid is added to the liquid at the bottom of the column after coming from the coalescer, so that the secondary gas and the liquid removed in the centrifugal separator do not require separate treatment.

In order to improve even further the liquid separation in the centrifugal separator, openings are preferably provided in accordance with the invention at the top of the swirl tubes for discharging liquid to the space between the trays outside the swirl tubes. This has the advantage that less secondary gas is carried to the space between the trays.

The invention will now be further illustrated with reference to the accompanying drawings.

- Fig. 1 is a schematic vertical sectional view of a column according to an embodiment of the invention;
- Fig. 2 is a horizontal sectional view of the column taken along the line II - II of Fig. 1; and
- Fig. 3 is a vertical sectional view of a swirl tube of the centrifugal separator according to an embodiment of the invention.

The normally vertical column 1 according to the depicted embodiment of the invention comprises a supply and distribution assembly 3 connected to a gas inlet 2 and arranged at some distance above the lower part 4 of the column 1 which functions as a liquid-collecting space. The part 4 is provided with a liquid outlet 5.

At some distance above the supply and distribution assembly 3 is a horizontal coalescer 6, which extends horizontally over the whole cross-section of the column 1. At some distance above the coalescer 6 is a centrifugal separator 7, which also extends over the whole cross-section of the column 1. The centrifugal separator 7 is situated at some distance below gas outlet 8. A liquid discharge pipe 9 runs down from the centrifugal separator 7, through the horizontal coalescer 6, along the assembly 3 (see Fig. 2) and then into the liquid collecting space 4.

The supply and distribution assembly 3 consists of a horizontally extending box-like structure connected to the inlet 2 and enclosed by a vertical front wall 10 attached around the gas inlet 2 and a vertical rear wall 11, as well as an upper wall 12 and a lower wall 13. The last two walls 12 and 13 run horizontally, extend over practically the entire diameter of the column 1 and have a trapezoidal shape. The two vertical sides of the supply and distribution assembly 3 between the walls 10 and 11 are open and between the upper and lower walls 12 and 13 there are arranged vertical guide vanes 14 which project through the said open sides to outside the supply and distribution assembly 3. The vanes 14 are grouped in two grids of vanes disposed one behind the other, looking in the direction of flow. The vanes 14 each comprise a part 16 running almost parallel with the direction of flow 15 and a part 17 substantially perpendicular thereto.

The coalescer 6 comprises two horizontal supporting means 18 and 19 which are arranged in the column 1 at some distance from each other, and between them a coalescer bed 33 consisting of layers of metal gauze.

The centrifugal separator 7 comprises two horizontal trays 20 and 21 (see Fig. 3), as well as a

number of vertical swirl tubes 22, one of which is depicted in Fig. 3.

The swirl tube 22 is open at both ends and mounted with its bottom end 23 in an opening 24 of the lower tray 20. In the lower part of the swirl tube 22 are means in the form of inclined vanes 25 to impart rotary movement to the gas flowing in via the opening 24. In the upper part of the swirl tubes 22 are vertical slits 26. The open top end 27 of the swirl tubes 22 is situated at a small distance below the upper tray 21.

In the upper tray 21 are two sorts of openings, viz. coaxial openings 28 wherein vertical tube pieces 29 are arranged and openings 30 wherein vertical tubelets 31 are arranged. The tube pieces 29 are coaxial with the swirl tubes 22, have a smaller diameter than the swirl tubes 22 and run down and enter the swirl tubes 22. The tubelets 31 of relatively small diameter are further from the axis of the closest tube piece 29 than the radius of the swirl tubes 22.

The liquid discharge pipe 9 illustrated in Fig. 1 opens out at the top into the space between the trays 20 and 21, outside the swirl tubes 22.

The depicted device operates as follows:

Liquid-containing gas is fed via the gas inlet 2 into the supply and distribution assembly 3 and the gas is deflected laterally by the guide vanes 14 and distributed over the column cross-section. Larger quantities of liquid carried along with the gas are separated from the gas by the guide vanes 14 and this liquid falls directly into the liquid-collecting space 4.

In the meantime the gas flows upwards in the column 1 and passes the coalescer 6. A better distribution of the gas over the column cross-section is obtained by the pressure drop across the coalescer 6. During this passage, small liquid droplets coalesce into larger ones and, depending on the gas velocity, a smaller or larger quantity of liquid showers down out of the coalescer 6, finally landing in the space 4. In the space between the supply and distribution assembly 3 and the coalescer 6 the descending liquid will to some extent take with it liquid from the gas, so that the coalescing action of the coalescer 6 extends downwards.

The gas flowing up and out of the coalescer 6, which still contains an amount of liquid in the form of coalesced drops, the amount depending on its speed, distributes itself over the swirl tubes of the centrifugal separator 7.

In the swirl tubes 22 a rotary movement is imparted to this gas, whereby the liquid preferentially moistens the tube wall 22 and the gas preferentially flows upwards and leaves the swirl tubes 22 via the tube piece 28 (the "primary" gas). The liquid is driven up in the form of a film along the tube wall 22 under the influence of the upwardly flowing gas and, via the slits 26 and the annular space between the tube piece 29, the top 27 of the swirl tubes 22 and the bottom of the upper tray 21, arrives in the space between trays 20 and 21 outside the swirl tubes 22. A certain amount of "secondary" gas is also carried along with the liquid into this space. In this space a separation takes place between the liquid and the secondary gas under the influence of gravity. The liquid flows via the means for the discharge of liquid from the space between the trays 20 and 21 outside the swirl tubes 22 in the form of the liquid discharge pipe 9 to the space 4, without again coming into contact with the gas flowing through the column 1, and the secondary gas flows via the means for the discharge of secondary gas from the space between the trays 20 and 21 outside the swirl tubes 22 in the form of the tubelets 29 to the space above the centrifugal separator 7, where it is added to the primary gas from the tube pieces 28. The gas is removed from the column via the gas outlet 8 and the liquid via the liquid outlet 5.

Claims

1. Vertical column (1) for removing a liquid from a gas having a gas inlet (2), a liquid outlet (5) arranged below the gas inlet (2) and a gas outlet (8) arranged above the gas inlet (2), in which between the gas inlet (2) and the gas outlet (8) and over the whole cross-section of the column (1) a centrifugal liquid separator (7) is arranged, which centrifugal liquid separator (7) comprises two horizontal trays (20, 21) between which vertical open-ended swirl tubes (22) extend, each from an opening (24) in the lower tray (20) to some distance below a coaxial opening (28) in the upper tray (21), means (30) for the discharge of secondary gas and of liquid from the space between the trays (20, 21) outside the swirl tubes (22), and means (25) provided in the lower part of the swirl tubes (22) to impart to the gas a rotary movement about a vertical axis, characterized in that a horizontal coalescer (6) is arranged between the gas inlet (2) and the centrifugal liquid separator (7) and over the whole cross-section of the column (1), and in that the gas inlet (2) is provided with a supply and distribution assembly (3) extending horizontally in the column (1), the assembly (3) consisting of a box-like structure extending horizontally across the column having at least one open vertical side with a grid of guide vanes (14) disposed one behind the other across the column.

2. Column (1) according to claim 1, wherein the horizontal coalescer (6) consists of a bed (33) of layers of metal gauze.

3. Column (1) according to claim 1, wherein the horizontal coalescer (6) consists of a layer of vanes.

4. Column (1) according to claim 1, wherein the horizontal coalescer (6) consists of a layer of structured packing.

Patentansprüche

1. Stehende Kolonne (1) zum Abscheiden einer Flüssigkeit aus einem Gas, umfassend einen Gaseinlaß (2), einen unter dem Gaseinlaß (2) angeordneten Flüssigkeitsauslaß (5) und einen über dem Gaseinlaß (2) angeordneten Gasauslaß (8), bei welcher zwischen dem Gaseinlaß (2) und dem Gasauslaß (8) und über den gesamten Querschnitt der Kolonne (1) ein Zentrifugal-Flüssigkeitsabscheider (7) angeordnet ist, welcher zwei waagerechte Böden (20, 21) aufweist, zwischen denen sich senkrechte, an den Enden offene Wirbelrohre (22) je von einer Öffnung (24) im unteren Boden (20) bis zu einer Stelle in einigem Abstand unter einer gleichachsigen Öffnung (28) im oberen Boden (21) erstrecken, Einrichtungen (30) zum Abführen von Sekundärgas und Flüssigkeit aus dem zwischen den Böden (20, 21) außerhalb der Wirbelrohre (22) gelegenen Raum, und im unteren Abschnitt der Wirbelrohre (22) angeordnete Einrichtungen (25) zum Versetzen des Gases in eine Drallbewegung um eine senkrechte Achse, dadurch gekennzeichnet, daß zwischen dem Gaseinlaß (2) und dem Zentrifugal-Flüssigkeitsabscheider (7) und über dem gesamten Querschnitt der Kolonne (1) ein waagerechter Coalescer (6) angeordnet ist, und daß der Gaseinlaß (2) mit einer sich in der Kolonne (1) waagerecht erstreckenden Zuführ- und Verteiler-Vorrichtung (3) versehen ist, welche aus einem sich waagerecht quer durch die Kolonne erstreckenden kastenähnlichen Aufbau besteht, der wenigstens eine offene senkrechte Seite mit einem Gitter aus Leitschaufeln (14) umfaßt, die quer durch die Kolonne hintereinander angeordnet sind.

2. Kolonne (1) nach Anspruch 1, bei welcher der waagerechte Coalescer (6) aus einem Bett (33) aus Metallgewebe-Lagen besteht.

3. Kolonne (1) nach Anspruch 1, bei welcher der waagerechte Coalescer (6) aus einer Lage Leitschaufeln besteht.

4. Kolonne (1) nach Anspruch 1, bei welcher der waagerechte Coalescer (6) aus einer Lage strukturierter Füllkörper besteht.

Revendications

1. Colonne verticale (1) pour éliminer un liquide d'un gaz ayant une entrée pour gaz (2) une sortie pour liquide (5) située au-dessous de l'entrée pour gaz (2) et une sortie pour gaz (8) située au-dessus de l'entrée pour gaz (2), dans laquelle entre l'entrée pour gaz (2) et la sortie pour gaz (8) et sur toute la section transversale de la colonne (1) est disposé un séparateur centrifuge de liquide (7), lequel séparateur centrifuge de liquide (7) comprend deux plateaux horizontaux (20, 21) entre lesquels s'étendent des tubes de tourbillonnement verticaux (22) à extrémités ouvertes, chacun depuis une ouverture (24) dans le plateau inférieur (20) jusqu'à une certaine distance au-dessous d'une ouverture coaxiale (28) dans le plateau supérieur (21), des moyens (30) pour la décharge de gaz secondaire et de liquide de l'espace entre les plateaux (20, 21) à l'extérieur des tubes de tourbillonnement (22) et des moyens (25) prévus dans la partie inférieure des tubes de tourbillonnement (22) pour imprimer au gaz un mouvement de rotation autour d'un axe vertical, caractérisée en ce qu'un coalesceur horizontal (6) est disposé entre l'entrée pour gaz (2) et le séparateur centrifuge de liquide (7) et sur toute la section transversale de la colonne (1), et en ce que l'entrée pour gaz (2) est pourvue d'un ensemble (3) d'alimentation et de distribution s'étendant horizontalement dans la colonne (1) l'ensemble (3) étant constitué d'une structure en forme de boîte s'étendant horizontalement en travers de la colonne ayant au moins un côté vertical ouvert avec une grille d'ailettes de guidage (14) disposées les unes derrière les autres en travers de la colonne.

2. Colonne (1) selon la revendication 1, dans laquelle le coalesceur horizontal (6') consiste en un lit (33) de couches de toile métallique.

3. Colonne (1) selon la revendication 1, dans laquelle le coalesceur horizontal (6) consiste en une couche d'ailettes.

4. Colonne (1) selon la revendication 1, dans laquelle le coalesceur (6) consiste en une couche de garnissage structure.

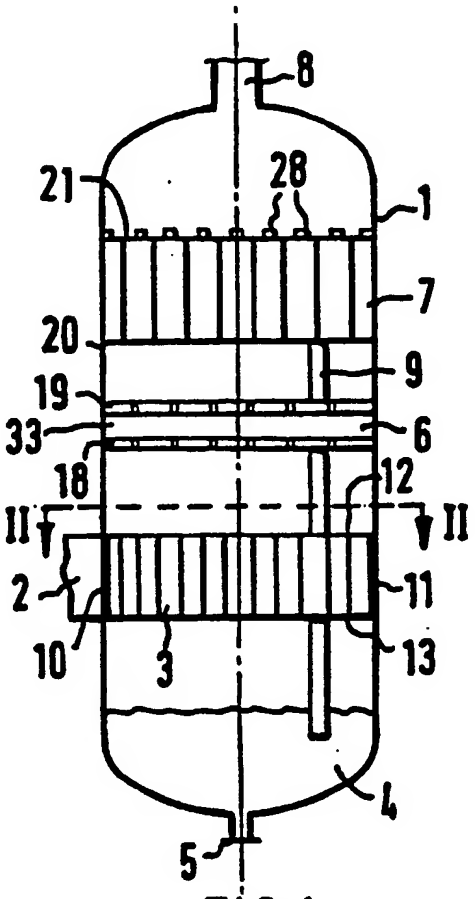

FIG.1

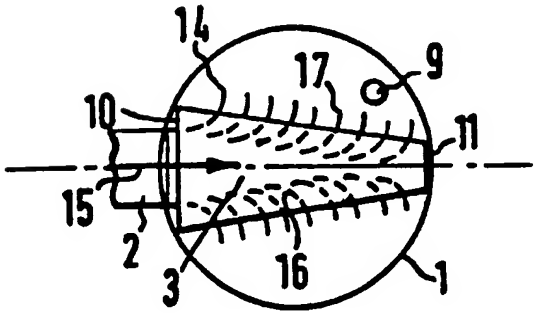

FIG.2

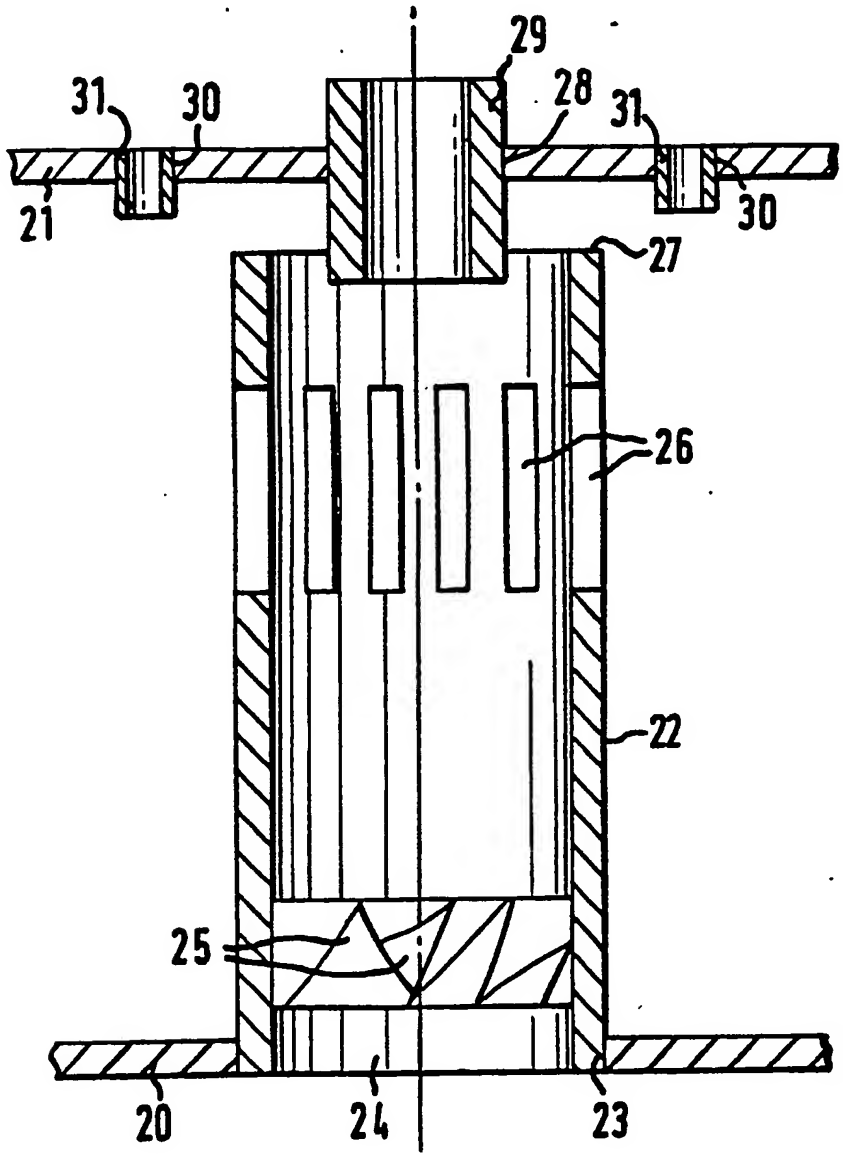

FIG.3